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Dear Mr. Smith:

I thought I knew a few things about radio before I started studying your Course, but found out that I was mistaken. I am Parts Manager for a large automobile dealer here and do my radio repairing in my home at night. I repair automobile radios for eight auto concerns and fix home sets too. I get more work than I can do. The NRI Course has really shown me the right way to service radios - it's all that you claim and more, too.

R.B.R., Kentucky

NATIONAL RADIO INSTITUTE
WASHINGTON, D. C.

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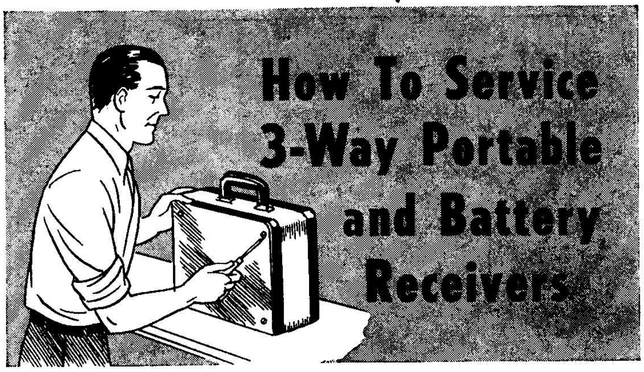


How To Service 3-Way Portable and Battery Receivers

THERE are a great many battery and portable sets both in cities and in the country, so it is well worth your while to learn how to service them. That is what this RSM Booklet is going to show you. In it, we will follow our usual procedure of describing the technical differences between these receivers and those you have studied previously. Then, we will show you how to locate the defects that are particularly apt to occur in portable and battery receivers.

Of course, any radio that can be carried is portable. However, this name is most usually applied to a type of set known as the three-way portable. This type of receiver is not only light in weight, it can be operated anywhere, because it is designed to obtain its operating voltages from any 110-volt a.c. or d.c. power line, or from self-contained batteries.

You are already familiar with the a.c.-d.c. receiver. Obviously, B batteries could be substituted for the B supply, and 6-volt tube filaments could be put in parallel and operated from a 6-volt storage battery. However, you certainly couldn't class a set using a large storage battery as a portable set. For this reason, tube manufacturers brought out first the 2-volt series of tubes and more recently, a series of 1.4-volt filament tubes requiring very low current drain for filament supply. This has made possible the modern, relatively lightweight portable receiver.

Let's examine the circuits of some typical three-way portable receivers.

FIXING RADIOS

No. 31 How To Service Three-Way Portable and Battery Receivers

RADIO SERVICING METHODS

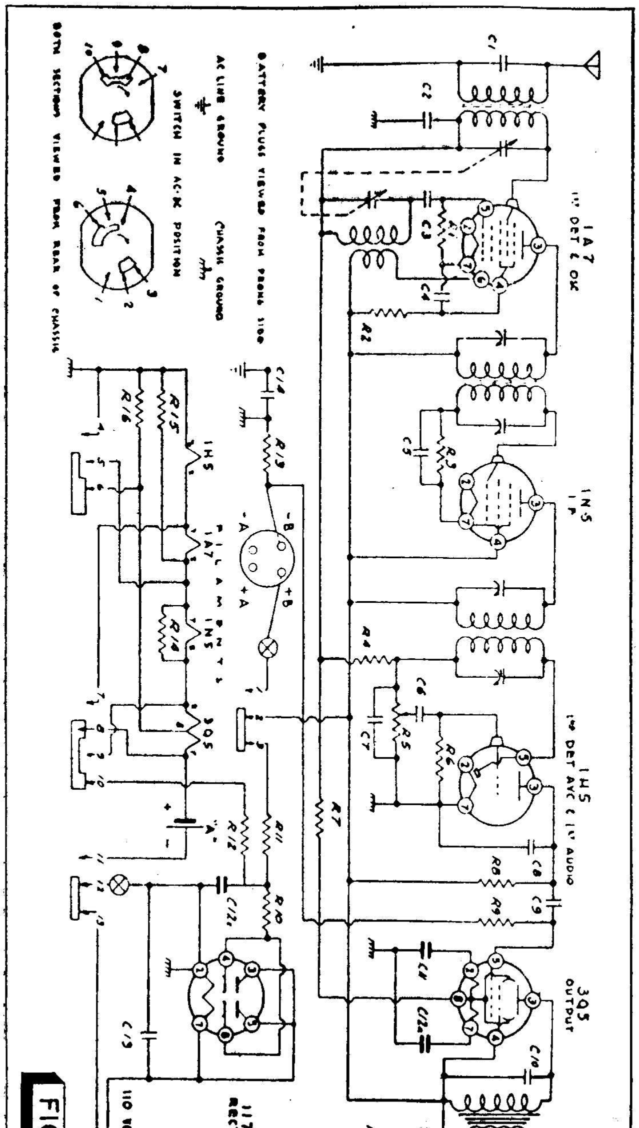


FIG. 1

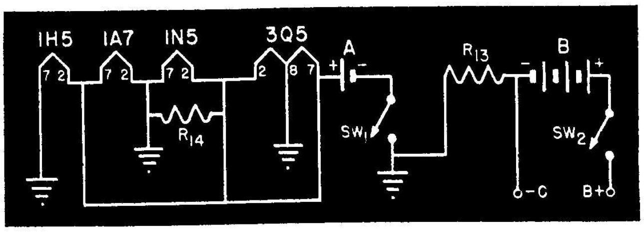
A TYPICAL THREE-WAY PORTABLE SET

Fig. *1* shows a diagram of a typical three-way portable receiver. This set is designed so that for battery operation, the tube filaments are connected in parallel to a single 1½-volt A battery. For power-line operation, the tube filaments are connected in series and draw their current from the B supply. Notice this important fact—these are battery-type tubes, so their filaments must be supplied with d.c. They cannot operate directly from a.c.

Battery Operation. Fig. *2* shows a simplified sketch of the filament connections for battery operation. When the change-over switch is thrown to the "battery" position, it connects the filaments as shown here, so that they are in parallel across the 1½-volt A battery. Notice the 3Q5 tube. This tube has a 3-volt filament if terminals 2 and 7 are used alone. However, the filament is tapped; connecting the two halves in parallel, as shown here, permits the filament to be operated from 1.5 volts. For simplicity, the change-over switch connections have been eliminated from this figure.

The B supply for battery operation is obtained from a 90-volt B battery. No C battery is used. The only tube requiring bias is the 3Q5, and its bias is obtained from

FIG. 2. When the change-over switch is thrown to the "Battery" position, the filament circuit in Fig. *1* is as shown below. Notice that one terminal of each filament is grounded, and that the other terminal is connected to A+, so the filaments are in parallel. ON-OFF switches SW_1 and SW_2 are ganged together, and they open both the A and the B circuits when turned off. Opening the A circuit would be sufficient to stop set operation, but the B circuit is also opened to prevent draining the B battery through leakage paths. (The "ground" symbol here represents a connection to the set chassis.)



the drop across R_{13}, as you can see by tracing the grid return circuit of the 3Q5 tube in Fig. *1*. All plate currents flow from B— to chassis through this resistor.

Power-Line Operation. Fig. *3* shows a simplified sketch of the connections for power-line operation. Now the tube filaments are in series. (The rectifier tube has a 117-volt filament, which is connected directly across the a.c. power line.) Resistor R_{12} drops the B-supply voltage to about 7.5 volts, the amount required by the other tube filaments. The rectifier tube must have a high current capacity, for it must supply a filament current of 50 ma. for these tubes in addition to the normal B-supply current.

Resistor R_{12} and condensers C_{12a} and C_{12c} act as a filter to smooth out the filament supply.

Notice the other shunt resistors and condensers in this filament circuit. Resistor R_{15} is in parallel with the filaments of the 1H5 and 1A7 tubes, R_{14} is in parallel with the filament of the 1N5, and R_{16} is in parallel with all the tube filaments except section *8-7* of the 3Q5. This arrangement is necessary because the filaments of these tubes are also the cathodes; consequently, both plate current and filament current must flow through them. Since the tubes are in series, all the plate current for, say the 1N5, would have to flow from ground through the filaments of the 1H5 and the 1A7 if R_{15} were not in the circuit. This current flow through these filaments would increase the voltage drop across them above the desired value. To prevent this from happening, R_{15} is included in the circuit as a shunt resistor; if its value is properly chosen, R_{15} carries most of the plate current for the 1N5 (and for the 3Q5), and little of it flows through the 1H5 and 1A7 filaments. Similarly, R_{14} shunts most of the plate current of the 3Q5 past the filament of the 1N5, and R_{16} shunts half of the plate current of the 3Q5 past all the filaments.

The resistances of R_{14}, R_{15}, and R_{16} must be very carefully calculated by the set manufacturer. When you replace a resistor in a filament string of this sort, be sure you use a value that is close to the original.

Incidentally, on power-line operation, the voltage drop across the other three tube filaments furnishes the

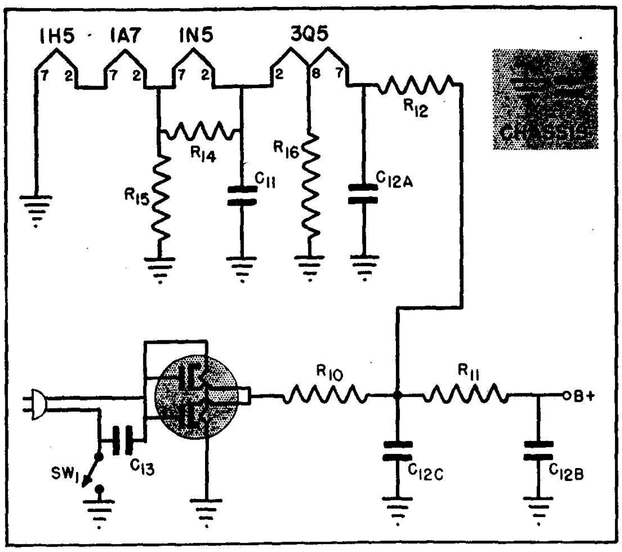


FIG. 3. This sketch shows the "power line" version of the filament circuit of Fig. *1*. The series filaments are supplied with power through R_{12} from the B supply.

bias for the 3Q5 tube. As you can see from Fig. *1*, the 3Q5 grid is connected to ground through R_9 and R_{13}. (There is no voltage across R_{13} on power-line operation, since current flows through it only when batteries are used.) This is the same as connecting the grid to the ground terminal of the 1H5 tube, the most negative point of the filament string. Consequently, the voltage drops across the 1H5, 1A7, and 1N5 filaments supply the bias for the 3Q5.

Condenser C_{11} in Fig. *3* is a high-capacity electrolytic. It acts as an a.f. by-pass condenser, preventing the a.f. components of the 3Q5 plate and screen-grid currents from flowing through the filaments of the other tubes.

This receiver will operate from a d.c. power line as well as from a.c., provided the power plug is connected to the power line so that the plate of the rectifier tube is made positive. Otherwise, the rectifier tube will block the passage of current. On a.c. operation, the line polarity is usually unimportant, although sometimes noise

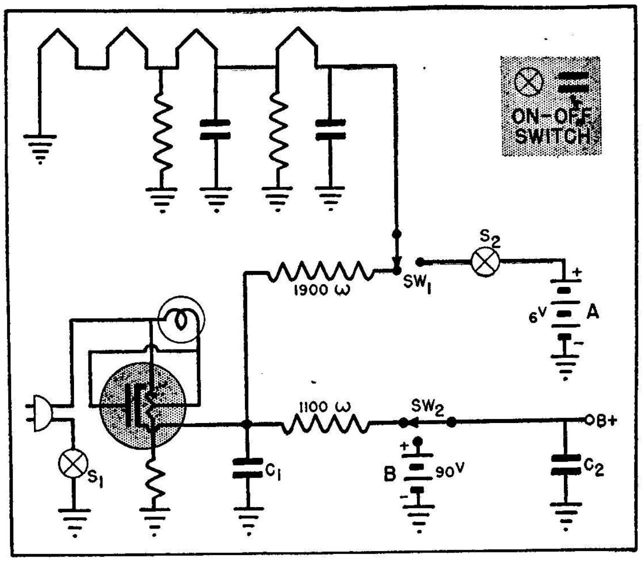


FIG. 4. Because the filaments stay in series, a much simpler change-over switch can be used in this circuit. Some sets of this type do not even use switches; the batteries are connected at all times. You can see this circuit by imagining that all three terminals of SW_1 are connected together to complete the A circuit, and all three terminals of SW_2 are connected together to complete the B circuit.

and hum can be cut down somewhat by reversing the line plug in the wall outlet.

THREE-WAY PORTABLE VARIATIONS

Fig. *4* shows a somewhat different filament arrangement for a three-way portable. Here, the tube filaments remain in series at all times. On power-line operation, they are supplied by the B supply; on battery operation, they are supplied by a small 6-volt dry-cell battery. To change from battery to power-line operation, the ganged switches SW_1 and SW_2 are thrown. Switches S_1 and S_2 are the on-off switches, and they are ganged with the volume-control shaft.

Incidentally, some sets use a 35- or 50-volt rectifier tube, plus a series filament resistance, as shown in Fig. *4*. More generally, however, a tube with a 117-volt filament is used, so that its filament can be connected directly across the power line.

► Fig. *5* shows another important type of three-way portable. This set is unique in two ways—it uses two power-output tubes and has an unusual method of changing from battery to power-line operation.

Notice that the control grids of the 3Q4 and the 117N7 power amplifier tubes are in parallel, and their plates are connected to the same output transformer (the 117N7 is connected to a tap on the transformer for a better impedance match). Therefore, either can be the output tube; the power supply used determines which one operates.

Fig. *6* gives more details of the filament circuit, and of the method of changing from battery to power-line operation. On the back of the receiver chassis, there is a polarized receptacle—one into which the receiver power plug will fit, but only in one way, because the receptacle openings are a different size, and the plug prongs are specially shaped.

When battery operation is desired, the line plug is inserted into the receptacle. When properly placed, the plug prong marked *Y* connects B— and A— through the on-off switch SW_1 to the set chassis. (The other side of the plug, *X*, does not connect to anything in this receptacle.) By tracing the filament circuit in Fig. *6*, you will see that this completes the *A* battery circuit through SW_2 and through the filaments of the 3Q4, 1T4, 1R5, 1T4, and 1S5 tubes. Therefore, on battery operation, all these tubes operate from the A supply, and, of course, the 117N7 tube filament is not energized.

When power-line operation is desired, the plug is withdrawn from this receptacle (thus disconnecting the batteries from the set chassis) and plugged into a wall outlet. The filament of the 117N7 tube now is energized by the power line. All other tubes *except the 3Q4* are connected, through R_{15}, in parallel with the 117N7 bias resistor R_{16}. Therefore, a portion of the d.c. plate current of the 117N7 amplifier section passes through these tube filaments and provides the necessary filament current. However, none of this current can flow through the 3Q4 filament, because its circuit is broken at the

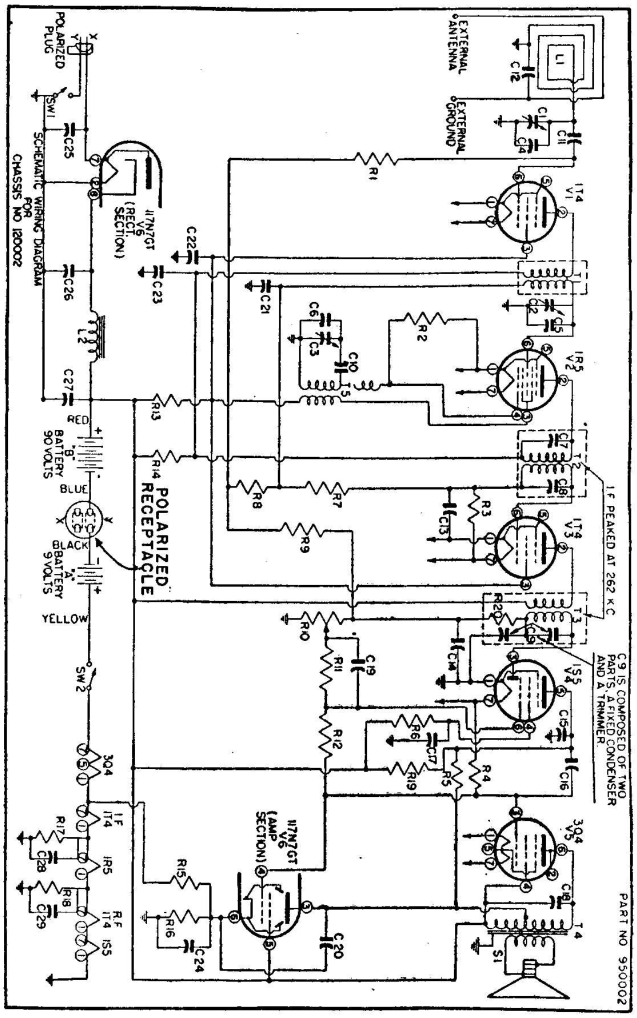


FIG. 5. The use of a different power output tube for power-line operation greatly improves the output power and the tone quality of this type of portable. Notice the condenser symbols used here. Some manufacturers have adopted the special "curved line" symbol shown here to represent fixed by-pass and filter condensers. A careful examination will show that the trimmer condenser "curved plate" symbol has an arrowhead, and that the tuning condenser symbols have a straight arrow drawn through them.

receptacle—the power plug is not in this receptacle on power-line operation.

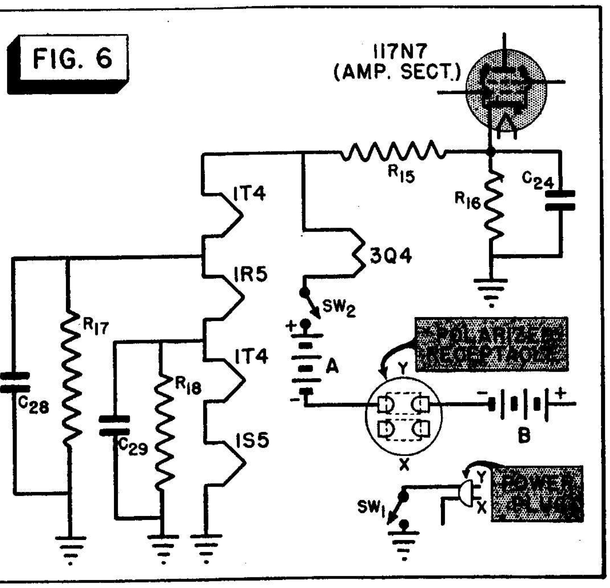
In Fig. *6*, condensers C_{24}, C_{28}, and C_{29} by-pass the a.c. components of the plate currents, and R_{15} reduces the current flow through the filaments to the desired value. Resistors R_{17} and R_{18} are filament shunt resistors.

Going back to Fig. *5*, we see that resistor R_4 is the power-tube grid resistor. On battery operation of the 3Q4, the bias for this tube is obtained from the filament-voltage drop across the 1T4, 1R5, and 1T4 tubes. Since R_4 connects to terminal *7* of the 1S5 tube, the drop across this latter tube filament is not used as bias.

► Inverse feedback, a feature that improves the fidelity, is obtained on both power-line and battery operation, because resistor R_{12} is connected so as to feed energy from the grid of the output tube back to the grid circuit of the 1S5 tube. Since the 1S5 tube inverts the phase of the signal, this feedback is out of phase with the grid input signal to this tube, so inverse feedback is obtained.

Recharging Batteries. In some receivers, the batteries are connected in the circuit at all times. To see how

FIG. 6



such a set works, imagine that we connect together all three terminals of switch SW_1 in Fig. *4*, and do the same for the terminals of SW_2. Now, when the power plug is not in a wall outlet, the set will operate from the batteries. When the power plug is connected to a line, the power-supply voltage will be a little higher than the corresponding battery voltages, especially if the batteries have begun to run down. Therefore, the set will operate from the power line, and a small reverse current will flow through the batteries. Dry batteries cannot be recharged by this reverse current, but the polarizing film of hydrogen gas that forms around the positive pole can be dissipated by it, thus lowering the internal resistance of the battery and prolonging its life. You may find some manufacturer's literature that states that this is a recharging process, but it is not; it is a depolarization of the battery, rather than a true charging such as could be carried on with a storage battery.

A STORAGE-BATTERY PORTABLE

The development of low-filament-drain tubes has led to the production of one portable using a special 2-volt lightweight storage-battery cell. A diagram of this set is shown in Fig. *7*.

The tube filaments are connected in parallel, and operate directly from the 2-volt storage cell. The cell also operates a vibrator power supply of the synchronous vibrator type, which furnishes the necessary B-supply voltage.

The set operates from the storage battery all the time. However, when the set is connected to an a.c. power line, the a.c. supply is stepped down by a transformer and applied to a copper oxide rectifier unit that charges the storage battery. The power selector switch has four positions, marked "off," "battery," "a.c. line," and "charging." When the switch is thrown to the *charging* position, the set does not operate, but the power line charges the battery. In the *a.c. line* position, the battery charges from the line while the set operates from the battery.

This receiver differs in several ways from other portables. It is not a true three-way type, because it does not

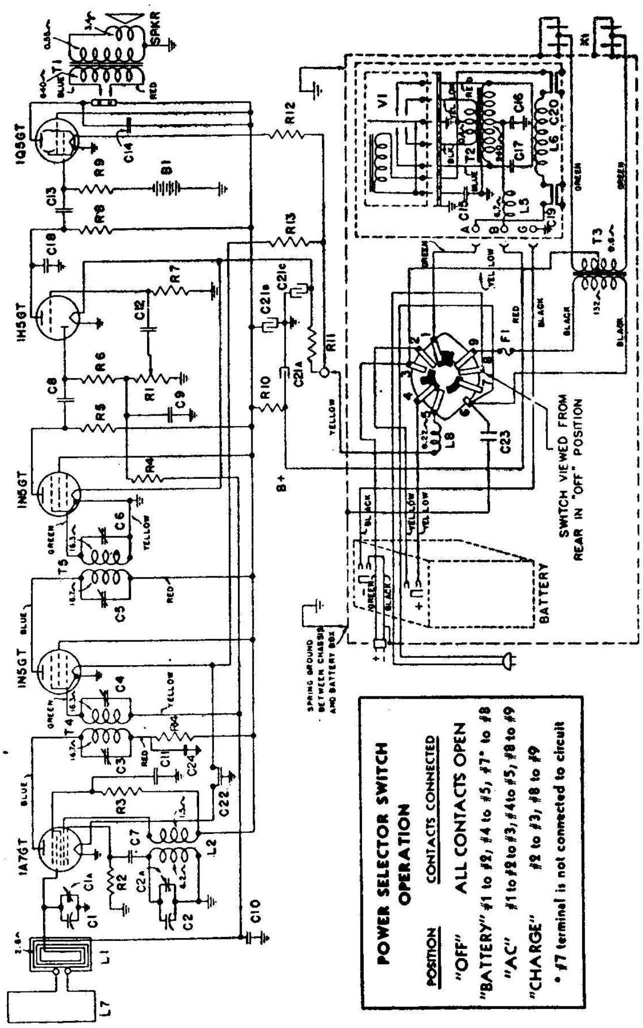


FIG. 7. This circuit is shown only to acquaint you with the general features of this type of portable. The set uses a special 2-volt vibrator V_1, of the synchronous type, as a means of getting the B supply. Notice the special shielding needed around the power supply to keep down vibrator hash. The state of charge of the 2-volt cell is indicated by a built-in hydrometer feature.

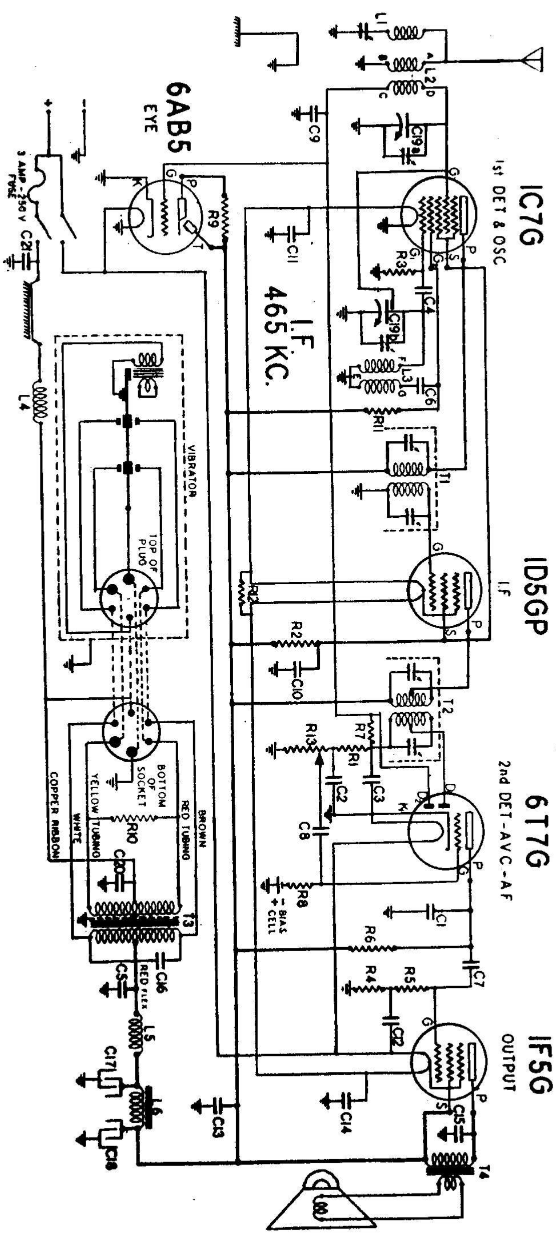


FIG. 8. This type of radio is designed for operation in regions where there are no power lines. This model gives efficient operation from a 6-volt storage battery. Every effort is made to reduce battery drain; for example, some of the tubes are 2-volt types with their filaments in series. (Some of these sets use 6-volt tubes throughout.)

operate from d.c. power lines—the power line must be a.c. However, in appearance it resembles the three-way types previously described, and its total weight, with battery, is only 16 pounds. Thus, it is portable.

BATTERY SETS

Battery sets are of several major types. In one, all power comes from A, B, and C batteries. In the past, 5-volt, 3.3-volt, and 2-volt tubes were used in these sets; now, 1.4-volt tubes are generally used.

Many of the larger console receivers, particularly those found where there are no power lines, operate from 6-volt storage batteries, and use a vibrator power supply like that in an auto set to furnish the B and C voltages. Such a set is shown in Fig. *8*. Notice that a synchronous vibrator is used, rather than a rectifier; this is usual in these sets, and is done to keep battery drain as low as possible. The 6-volt storage battery is kept charged by a wind charger, a gasoline-engine-driven generator, a 32-volt Delco power plant, or by having it charged at a service station (and using a rental battery while the original is being charged). The servicing of these receivers is basically like that of auto sets, which you have already studied, except, of course, you do not have ignition interference to worry about.

Since battery sets are designed primarily for use in outlying communities, they are usually both sensitive and selective. The tone quality may not be remarkable, because they are strictly limited in their power output, but it will be at least acceptable in the better sets.

► Now let's see how to service these receivers. We'll devote most of our attention to the three-way portable, since the troubles that occur in this set on battery operation are much the same as those that occur in all battery-operated sets.

PRELIMINARY SERVICE PROCEDURES

Before you start to service a three-way portable, determine just how the faulty operation occurs. If it occurs on *both* power-line and battery operation, the trouble is probably a defective signal circuit, a bad tube, or an electrode supply defect. If the defect occurs only

on *battery* operation, the trouble is in the batteries or in the circuits that are used only for battery operation. When there is trouble on *power-line* operation only, it lies in the a.c.-d.c. power-supply system or in the circuits that are active only on power-line operation.

When the trouble occurs on *both* power-line and battery operation, use the usual methods of localization. Usually it is simplest to operate from the a.c. power line and treat the receiver as you would an a.c.-d.c. set. Remember—you cannot pull tubes out of these sets in your localization procedures.

► As a matter of fact, it is dangerous to pull out tubes in a three-way portable; you might burn the tube out when you put it back in. For example, in Fig. *9*, condenser C_3 is a high-capacity electrolytic condenser. If you pull out a tube, this condenser will charge up through R_1 to the full 90-volt output of the B supply. Then, when you put the tube back in, the high current flow that results from discharging this condenser through the low-resistance filament string is practically certain to burn out a filament. Always keep this fact in mind.

Furthermore, be careful when you replace a burned-out tube. Before installing the replacement, make sure that the set is turned off and that the electrolytic filter condensers of the filament string are discharged—otherwise the effect just described may occur.

► Don't be alarmed if you cannot observe any filament glow in modern battery tubes. The very low power used by these tubes means that there will be little visible light, so don't depend on observation to tell you whether tubes are good or not. Check them in a tube checker if in doubt.

► The replacement batteries used in three-way portable sets must usually be exact duplicates, physically and electrically, of the originals, to provide the proper voltages and fit the space allotted to them. Sometimes these batteries are not easily obtained, or the receiver owner may not want battery operation any longer. In all cases except that of the storage-battery set described earlier, the batteries can be removed and the set used as a power-line-operated receiver. If you do this, be sure the

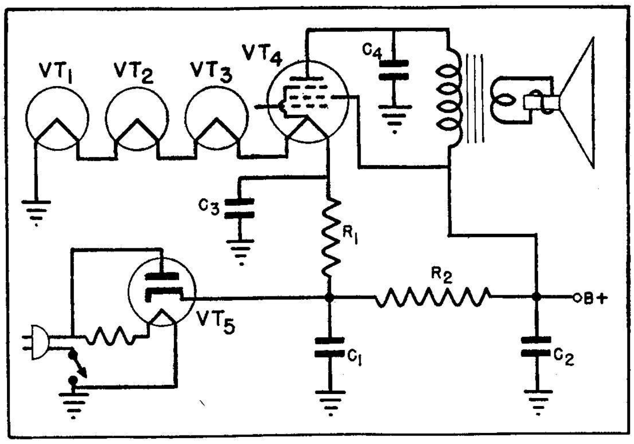


FIG. 9. This is the filament connection for power-line operation of one type of portable. (Battery circuit is not shown.) The filament supply filter condenser C_3 is a high-capacity electrolytic; typical values range from 50 to 200 mfd. If a tube filament burns out, there will be little voltage drop across R_1, so C_8 can charge up to the full B voltage. Always be sure C_3 is discharged (short its terminals with a test lead or screwdriver, with the set turned off) before replacing burned-out tubes.

battery cables are clearly marked so that in the future, replacements can be easily put in, and be sure the leads are taped or positioned so that they cannot short to each other. Incidentally, it is always advisable to remove exhausted batteries, for the zinc cases of the cells may be punctured and allow the electrolyte to leak out and damage the case of the receiver.

Now let's see what to do about specific receiver defects.

SET DEFECTIVE ONLY ON POWER-LINE OPERATION

In this section, we will assume that the receiver operates on its batteries, but is defective when you try power-line operation.

Dead Receiver. Check to see if the rectifier tube is good. Since this has a high-voltage filament, you should be able to see whether it lights up. If it does not, check it in a tube tester. Be on the lookout for a broken lead

in the power cord near the power cord plug. Usually a portable is connected to and disconnected from the power line rather often, so its power cord gets much more wear than does that of the standard receiver.

If a line-cord resistor is used (the rectifier tube is not a 117-volt type), check it also for an open.

If the rectifier tube lights, check the output voltage of the power supply. Check the B supply first. If the 1.4-volt tubes have their filaments in series with the cathode of the power output tube, be sure this tube is getting plate voltage. An open in its plate circuit will kill all operation.

Since the set plays on batteries, the 1.4-volt tubes must be good. However, there is always the possibility that a defect in the switching system used to switch over to power-line operation is preventing these tubes from receiving the proper filament voltage.

► If the power line is d.c., watch for improper polarity of the power plug. Try reversing it in the wall outlet if the rectifier tube lights but there is no B voltage.

Oscillator Failure. A rather common defect of these receivers is failure of the oscillator stage to function. Fig. *10* shows the oscillator-first-detector section of the receiver in Fig. *5*. As you know, you can readily determine if the oscillator is working by measuring the d.c. voltage across the oscillator grid resistor R_2. A high-resistance d.c. voltmeter should be used, and the negative voltmeter probe should be placed on grid terminal *4* of the oscillator section of this tube. A reading of 10 volts or more indicates that the oscillator is working, but no reading or very little reading shows that it is not.

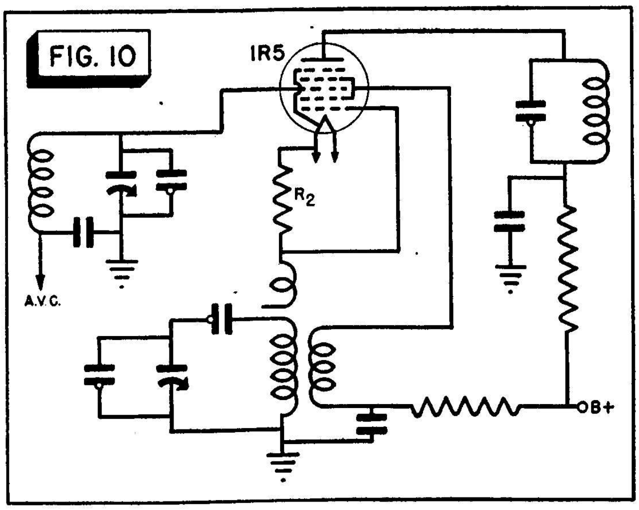
If it is not, first check the operating voltages, particularly the filament voltage. Low filament voltage is the most common cause of oscillator failure, when battery operation is normal. Check the line voltage, since low line voltage will reduce all the filament voltages. (Frequently you will find that low line voltage is the cause of the trouble when a receiver works all right in your shop but not in the customer's home.) If the line voltage is low, and is found to be *always* below normal, the filament voltage may be increased slightly by arranging for more current to flow through the filament.

If the line voltage appears normal, but the voltage across the 1.4-volt tube filaments is low, check their supply. If they get their voltage from the plate current of the power output tube, check to see if you have a weak output tube. Below-normal plate current will naturally reduce the voltage drops across the 1.4-volt tube filaments. Incidentally, this tube filament rating indicates the *average* voltage at which they will work. They are supposed to operate on any voltage between 1.2 and 1.65 volts. However, the oscillator-first-detector tube is somewhat critical in this respect, and some tubes will fail to work if the voltage drops below 1.3 volts.

If the filament voltage is below normal, and the drop is provided by a series resistor such as R_1 in Fig. *9*, then this resistance value may have increased slightly, or condenser C_3 may be somewhat leaky. Also, the B-supply voltage may be somewhat below normal because of a defect in condenser C_1, leakage in C_2, or low emission in the rectifier tube. If there are filament shunting resistors, one or more of these may have decreased in value. Any of these conditions will reduce the filament voltage.

Should you find the filament voltage to be normal on this tube, and it still does not function, try another tube,

FIG. 10



BURGESS	RAY-O-VAC	GENERAL	NAT'L CARBON	USALITE	ADVANCE	BRIGHT STAR	WINCHESTER	BOND
"A" BATTERIES								
4F	P94A	4FI	742	634	247	462	4816	4826
6F	P968	6FI	743	637	147	660	4814	4824
8F	P98A	8FI	741	635	147	860	4819	4829
8FL	P98L	8CFL	745	645	547	865	4813	
F4L				643				
4FL	P94L	3LI		642		465		
F4PI	P694A	4F4		639		646		
2F	P24A	2FI						
2F4	P698A	8F4	718	638	817	866	4817	4827
2F4L	P698L	8CF4	747	646		868	4815	4825
F4PIX				636	2476			4823
G3	EM83	3H3	746	683		361	4918	4928
G5	P85A	5H5	687			561		
FX	9							
"B" BATTERIES								
M30	P5530		482	640	284	30-33	6210	6220
B30	P5303	V30B	762	624	267	30-03	6218	3017
A30	430P	V30A		621	237	30-55		
A30M				622		30-50		
Z30	P7R30	V30AA	738	620				
A60	BB60P							
W30PI	P3A30	V30AAA	733					
W20PI		20AAAG						
W34		34AAAG						
W40	3A40P							

Charts like this show which batteries of one manufacturer correspond electrically and physically with those of another. Battery manufacturers also publish lists of the batteries used in the better known receivers. From such lists you or your parts supplier can choose a satisfactory replacement battery when an exact duplicate is not available.

regardless of the way the original tests in a tube checker. Also, sometimes the oscillator can be made more reliable by reducing the value of R_2 in Fig. *10* by 10% to 20%. (Watch for cases where this resistance has increased above its rated value.)

► If the above suggestions do not lead at once to the source of trouble, proceed to the usual localization tests. For a dead set, you can use signal tracing, signal injection, or the circuit disturbance steps made by touching tube top caps or measuring voltages.

Intermittent Reception. If the set is intermittently dead on power-line operation, but plays normally on battery operation, then the trouble must be in some portion of the power supply. Check to determine if the intermittent operation occurs at definite times in the day. If so, the trouble may be the result of line-voltage fluctuation.

At certain times of the day, particularly in the early morning and early evening hours, the electric lines may be so heavily loaded that the voltage drops considerably.

If voltage measurements prove this to be the case, you can try to make the oscillator work at the reduced voltage by changing its grid resistor or by using a new tube; if you don't succeed, there is little you can do except call the matter to the attention of the power company.

Sometimes the trouble will be caused by operating the receiver from an outlet that is already heavily loaded by lamps or other home devices. Try the set on another outlet, on a different branch of the electric circuit of the house.

► A trouble such as intermittent oscillation may be caused by the reverse of the above condition—the oscillation may occur when the line voltage rises above normal. Other intermittent conditions usually have the same causes as their more steady counterpart troubles, so we will describe them in the following sections.

Distortion. If distortion is present only on power-line operation, check the voltages at the various tube-socket terminals in the audio amplifier. You will probably find some abnormal voltage on the power-line operation. Bear in mind that the voltages on power-line operation are usually *somewhat* higher than those for battery operation. Compare both battery and power-line voltages to find the one that is radically different.

Check also for a gassy output tube, particularly if the set is so designed that a different output tube is used for power-line operation.

More gain is obtained from the higher d.c. voltages available on power-line operation, and there may be distortion caused by overloading if the volume control is turned up too high. This is not a receiver defect if the distortion clears up satisfactorily when the volume control is turned down somewhat.

Improperly centered voice coils and loosened cones may show up only when maximum volume is used. You will recognize these forms of distortion and can make the proper repair or replacement.

Hum. This trouble occurs only on a.c.-power-line operation. Usually defective filter condensers are to blame; also be on the lookout for cathode-to-heater leakage in the rectifier tube, since this will inject a high-voltage a.c. ripple into the circuit.

SET DEFECTIVE ON BATTERY OPERATION ONLY

For this section, we will assume that the receiver plays normally on the power line, but does not play satisfactorily when operated from its batteries.

Dead Set. If the set works O.K. from the power line but is dead on batteries, probably the batteries are at fault. Always check battery voltages with the set operating—batteries that test normal when the set is turned off may drop in voltage when it is turned on and a load is placed on them.

If you find it necessary to replace the batteries, you can get the right replacements by ordering duplicates of the originals. The factory manual for the receiver will generally give battery type numbers of several different battery manufacturers. Your jobber can also suggest the right replacement from charts furnished by the battery companies, if you will tell him the make and model number of the set and the types and number of the tubes used in it.

Intermittent Reception. Intermittent reception on battery operation only also indicates battery trouble, particularly when the set plays at first and then gradually fades out. Make a careful check of the battery voltages after the set has faded out. If any have dropped appreciably, replace the batteries.

Noise. Noise on battery operation and not on power-line operation may indicate defective batteries, but probably indicates loose connections to some battery. Check over the battery connections carefully, and go over the switch that changes the operation from the battery to the power line.